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The formation and ventilation of an Oxygen Minimum Zone in a simple model for latitudinally alternating zonal jets

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The eastern tropical North Atlantic (ETNA) features strongly deoxygenated waters between approximately 100-1000 meters depth, commonly referred to as oxygen minimum zone (OMZ). While observations suggest a prolonged intensification of this OMZ, it remains a challenge to discern to which degree this imbalance in oxygen consumption and ventilation is a forced trend or due to natural variability. As latitudinally alternating zonal jets (LAZJs) play an important role in ventilating the OMZ, changes in their intensity have been hypothesized to contribute to the observed long-term oxygen changes. In this study, we therefore investigate the role of LAZJs in driving the natural variability of OMZs on interannual to interdecadal time scales. To this end, we employ an advection-diffusion model coupled with a non-linear shallow water model, set up for ETNA. The advection-diffusion model carries a tracer mimicking oxygen, and the simple dynamical model is forced by an annually oscillating zonal mass flux confined to the near-equatorial band. The forcing generates mesoscale eddies at higher latitudes that lead to the formation of LAZJs. Although the model is forced only at the annual period, the model nevertheless exhibits decadal and multi-decadal variability in the ETNA OMZ in its spun-up state. The associated trends are sufficient to explain the observed trends in oxygen within the OMZ. Notable exceptions are the observed multi-decadal decrease in oxygen in the lower OMZ, and the sharp decrease in oxygen in the upper OMZ between 2006 and 2013.

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